Eastburn,

THE METRIC SYSTEM

BY

GEORGE EASTBURN, M.A.

AMERICAN METROLOGICAL SOCIETY.

FOUNDED 1873.

Objects.

1.—To improve existing systems of weights, measures, and moneys, and to bring them into relations of simple commensurability with each other.

2.—To secure universal adoption of common units of measure for quantities in physical observation or investigation, for which ordinary systems of metrology do not provide: such as divisions of barometer, thermometer, and densimeter; amount of work done by machines; amount of mechanical energy, active or potential, of bodies, as dependent on their motion or position; quantities of heat present in bodies of given temperatures, or generated by combustion or otherwise; quantity and intensity of electro-dynamic currents; aggregate and efficient power of prime movers; accelerative force of gravity; pressure of steam and atmosphere; and other matters analogous to these.

3.—To secure uniform usage as to standard *points of reference*, or physical conditions to which observations must be reduced for purposes of comparison; especially temperature and pressure to which are referred specific gravities of bodies; and the zero of longitude on the earth.

4.—To secure the use of the decimal system for denominations of weight, measure, and money derived from unit-bases, not necessarily excluding for practical purposes binary or other convenient divisions, but maintained along with such other methods, on account of facilities for calculation, reductions, and comparison of values, afforded by a system conforming to our numerical notation.

Modes of Operation.

1.—The society will endeavor to carry out its objects, by appeals to congress, state legislatures, boards of education, higher institutions of learning, and to directors and teachers of schools of every grade throughout the country, urging adoption of measures in their several spheres for diffusing information as to the present state of the world's metrology and recent progress in its reform, and specially for instructing the rising generation in these matters, to the end that our people may be early and fully prepared to act intelligently on the important questions connected with weights and measures.

2.—By invoking the aid and cooperation of bodies organized to consider questions of scientific or social interest, boards of trade, chambers of commerce, societies of engineers, industrial associations, professions and trades, in this country and elsewhere.

3.—By specially urging scientific bodies to open communication with similar bodies in other countries, with a view to general agreement on values to be henceforth uniformly given to units of measures and points of reference which particularly concern them; i. e. to the so-called constants of science.

4.—By memorializing congress in favor of laws requiring the use, in certain departments of the public service, of metric weights and measures, wherever such legislation may tend to relieve commerce of some of its burdens, to facilitate international communication, to promote international jurisprudence, and to familiarize our own people with the benefits of that system of metrology, with the least interference with their ordinary habits of thought or daily business.

5.—By direct appeals to the people through the public press, and by circulating so far as means allow, books and documents informing the public of the defects of the common system of weights and measures, the means most proper for its amendment, and the great advantages which the acceptance of a universal system would insure to all mankind.

Membership.

1.—Any person interested in the objects of this society may be elected a member at any meeting if unanimously nominated by the membership committee, to whom all propositions for membership shall be referred.

Communications for the AMERICAN METROLOGICAL SOCIETY may be addressed to JOHN K. REES, Secretary and Treasurer, Columbia College, New York City.

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THE METRIC SYSTEM.

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By GEORGE EASTBURN, M.A., Ph.D.

CHANGE, progress, improvement, are the watchwords of the nineteenth century.

In almost every phase of activity there has been a rejection of old modes and a substitution of new machinery. The spirit of the times is displayed in the selection of that which is best adapted to accomplish a desired end. Wise men recognize the fact that the true value of any piece of mechanism depends chiefly upon two things: first, its efficiency to do the work intended to be done, in the best possible manner; and, secondly, the consumption of the least possible time in the performance of said work. In other words, quality of work and consumption of time are the two all-important factors that enter into the calculation in determining the success of all industrial operations.

Previous to the application of steam and electricity to the development of civilization, international communication was so slow, and commercial intercourse so limited, that the means by which quantity and cost of articles of traffic were ascertained was a matter of secondary importance; but in this age of steam transportation and electrical communication, when we must do in a day an amount of work at which our grandfathers would have been contentedly engaged a month, when a brisk commerce is carried on with almost every nation of the earth, the mode of making calculations in business, and of representing the most common terms for expressing quantity in language that can be universally understood throughout the civilized world, becomes a

matter of most serious concern. Throughout the whole sphere of commercial and industrial operations, there is not a single piece of work executed that has not, in some way or other, the necessity of the use of some means of measurement connected with it. The grocer must use his weights and measures of capacity in disposing of his sugar, tea, and coffee, his molasses, fruits, and vegetables; the dealer in dry goods must use his measures of length in selling his muslins, cloths, silks, and velvets; the pharmacist and the chemist bring into constant requisition delicate weights and measures in their investigations; manufacturers, builders, and architects have measures and measurements in their minds almost continually; in fact, in all business calculations, quantity, indicated by measures of some kind or other, interposes the greatest obstacle in finding cost.

As there is such a need for weights and measures in order to render intercourse between man and man possible, it is of the highest importance that the system in use should be the best that can be devised. As weights and measures serve only as a piece of mechanism for ascertaining quantity in some particular phase of business or investigation, unquestionably that system of weights and measures is the best, *per se*, which is best adapted for the easy and rapid calculation of quantities in which are involved lines, surfaces, and volumes. The system which supplies these requisites is one in which the basic linear measure unit, or some division or some multiple of the same, is taken as the base of the unit for the computation of area, of capacity, and of weight; and to facilitate calculation, the notation is decimal.

This preface introduces to you my subject, entitled "The Metric System," which I propose to treat under the four following general divisions:

I. The objections to the measures now in use in the United States.

II. The advantages of the Metric System for the uses of measurements.

III. What has been done toward the universal adoption of the system.

IV. What should we, as citizens of the United States, do to secure its exclusive use at an early date in our country?

Objections to the Weights and Measures now in Use.

Under the first general head, I present the five following named objections :

1. Entire absence of any linear basis upon which quantities of capacities and of weight can be scientifically computed.
2. Multiplicity of names.
3. Differences of values in units of the same name.
4. Irregularity of the notation.
5. Dissimilarity to the weights and measures of any other nation.

To any one acquainted with the Metric System, it is evident that one of the most valuable features of a system of weights and measures is a common linear basis from which areas, volumes, capacities, and weights may be easily calculated. In the weights and measures now in use, having given the linear dimensions of a volume, there is no connecting commensurable unit by means of which the capacity and the weight may be directly found. The consequence of this incommensurability is the necessity and inconvenience of first calculating, from the linear dimensions given, the cubical contents of the capacity or volume, and then, by a long process of division or multiplication, the capacity or weight is found in the denomination desired.

Secondly, the multiplicity of names used to designate the units found in the various measures constitutes a very objectionable feature. In our best arithmetics there are not less than twenty different names given to units of length alone ; ten, to units of surface ; seven, to units of solidity ; fifteen, to units of capacity ; ten, to units of weight—making sixty-two arbitrary names of units to designate measurements of lines, areas, volumes, capacities, and weights alone. Such a diversified, meaningless, heterogeneous nomenclature as is found in naming the units used in our tables of weights and measures is enough to discourage any ordinary student in the hope of ever mastering them, and to cause the most exacting teacher to feel justified in excusing his pupils from a thorough knowledge of the tables and of their relations to one another.

The third objection that I offer to our weights and measures is that several of the units bearing the same name do not represent the same quantity. Let us first turn our attention to the weights. There are in practical use in our country to-day four different sets of weights; namely, the troy, the apothecaries', the avoirdupois, and the diamond.

The unit by which the values of the weights of different denominations are compared is the troy grain. Of the denomination of weights the values of whose units differ, I mention the ounce, the pound, the hundred-weight, and the ton. The troy ounce contains 480 grains, and the avoirdupois ounce 437½ grains. There are twelve ounces in a pound troy, and sixteen ounces in a pound avoirdupois. By multiplying 480 grains by 12 we obtain 5,760 grains in the troy pound, and by multiplying 437½ grains by 16 we obtain 7,000 grains in the avoirdupois pound; thus results the peculiar fact that an ounce of gold weighs 42½ grains more than an ounce of lead, but that a pound of lead weighs 1,240 grains more than a pound of gold. The ordinary hundred-weight contains 100 avoirdupois pounds, yet there is another hundred-weight, used in certain specified cases, which contains 112 pounds, and the two tons (each having in it twenty hundred-weight of its own kind) bear the same ratio to each other as the hundred-weights. The coal-dealer within the city limits of Philadelphia is required to furnish 2,240 pounds to the ton, while the dealer just beyond the city limits supplies his customer with 2,000 pounds to the ton. Let us now consider for a few moments the irregularities in the units of capacities having the same name. The measures of capacity known under the respective names of wine, ale or milk, and dry have each three denominations—the pint, the quart, and the gallon—of the same name; yet no two of these measures of the same name have the same capacity. Taking the cubic inch as the unit of comparison, the wine gallon contains 231 cubic inches, the ale or milk 282 cubic inches, and the dry 268.8 cubic inches; and dividing these numbers respectively by 4 and then by 2, we obtain the proportionate number of cubic inches for the quart and pint of each of the measures. In the absence of any legal provision requiring the testing and the sealing of weights and measures, one needs but little knowledge of the tricks of trade

to see the opportunities for practicing deceit upon the unwary customer. In fact, this diversity of capacity of units of the same name, and the appropriation of special titles to certain measures, open the way to an unconcealed injustice to a large class of producers of one of our most important daily necessities. I refer to the dairymen who reside along the lines of railroad communication with the city of Philadelphia. When the milk-dealer of this city contracts with the dairyman for milk, he demands, as his right, that he shall receive as a quart the milk quart, 70½ cubic inches. Then follows a mode of measurement which marks the transaction as unjust; for, after the milk has been brought to the city, the consumer is not allowed the privilege of buying the article as milk or ale, but it has been so changed, at least so far as measurement is concerned, that it is dealt out as wine, or 57¾ cubic inches to the quart. This state of affairs results from the omission of the United States Government to enforce the use of the only system of weights and measures which Congress has adopted, and in permitting local authorities and associations to establish their own customs in traffic. Just here I desire to impress upon your minds, that, of all the measures now in common use in this country, the only single one that is authorized by law is the troy pound, and that the legislation enacted with reference to that weight was not to legalize its use as an instrument to facilitate traffic, but merely to secure a uniform standard by which the coinage of England and the United States might be compared, and that the Metric System is *the only system of weights and measures* for which national legal authority can be claimed in our country.

The fourth objection which I bring to your notice is the irregularity of notation. This is exhibited in its perfection in the tables of linear and surface measures, in the former of which the factors in reductions are 12, 3, 5½, and 320, and in the latter 144, 9, 30¼, 160, and 640. In fact, this irregularity of notation, combined with the diversified variety of the tables of weights and measures, constitutes, in an educational point of view, the most forcible objection to them.

The difficulty of learning such a mass of arbitrary names, and of remembering so many irregular, uncorrelated numbers, is so

great that it takes months to acquire them, and constant reviews to retain them ; and the necessity of subjecting the young to so much practice in order to secure proficiency in the performance of the various forms of reduction, and a readiness in the manipulations of compound numbers, so multiplies the time and work in arithmetical instruction in the school-room that arithmetic must be taught continuously throughout a school course of seven or eight years ; while, if the Metric System were as thoroughly established in the place of our weights and measures as the use of our system of money is, all necessary practical arithmetic could be taught in a few months, and from one to two years' time would be saved in a boy's school life, and a great amount of mental vigor—now wasted in solving the intricacies of compound numbers—could be devoted to the more pleasant occupation of investigating some useful science, or of enjoying the beauties of the classics.

It seems to me that a thoughtful consideration of the above-mentioned facts should arouse every teacher to an inquiry respecting this unnecessary burden to school life, and eventually elicit from every well-wisher of our country an interest in the early introduction of some alleviating substitute.

In considering my fifth and final objection, I wish to correct a common mistake. Most people think that our measures and those of England are identical. Such is not the fact. While their names are nearly the same, their values differ widely. As England is the only country which, it is claimed, has weights and measures similar to ours, if I prove that these are unlike, my objection must be accepted as valid. Let us compare the values of some of the measures used in the two countries.

The discrepancies between the measures of England and the United States appear in those in constant use ; the United States wine gallon is equal to 0.83 British gallon, containing 277.27 cubic inches, which is used for all substances both dry and liquid, and which is one-eighth of the imperial bushel of 2218.19 cubic inches. Our bushel contains 2150.42 cubic inches ; hence, the United States bushel is equal to 0.97 British bushel; or, putting these statements in a different form, 83 British gallons are equal to 100 United States gallons, and

97 British bushels are equal to 100 United States bushels. The British hundred-weight and ton are twelve per cent. heavier than weights of the same name in our country. The British gallon, quart, and pint do not correspond with those of any one of our three measures. They are 20 per cent. greater than those of our wine measure, 3 per cent. greater than those of our dry measure, and 1.6 per cent. less than those of our ale measure.

No further argument is needed to show that our weights and measures are unlike those of any other country, and it seems to me that their objectionable features have been portrayed in such a light that every earnest advocate of progress and reform should be ready to cry out, "Cannot something more convenient be found to be substituted for these irrational, cumbersome weights and measures?" I can assure you it can. It has already been found. It is not new. It has so popularized itself by its own intrinsic merits that it is destined to be the universal means for the computation of all measurements. This great invention is the Metric System, which I now proceed to explain.

Adaptability of the Metric System.

The Metric System stands in strong contrast to the weights and measures in general use in our country. Its conception was the result of an earnest desire to establish for the whole civilized world a uniform, permanent, and universal system of weights and measures.

In examining the second general division of my subject, namely, "The advantages of the Metric System for the uses of measurements," I shall strive to show that these advantages prominently consist:

1. In the foundation of the system upon an adopted international linear unit as a basis.

2. In the facility in which the units of surface, capacity, volume, and weight are derived from this linear basis.

3. In the uniformity, the significance, and the simplicity of the nomenclature.

4. In having only one table of linear measure, one of capacity, and one of weight.

5. In the application of decimal notation to all divisions and multiples of the basic units of weights and measures.

The Metric System of Weights and Measures is so named because the fundamental linear base for the calculation of all the denominations of measures is the *meter*. The word "meter," etymologically considered, means, in the various Southern European languages, a measure; hence it is an appropriate name to give to that measure which stands as the invariable standard linear unit, upon which all other measures of whatsoever kind are to be dependent, and the system based upon it is as appropriately entitled the Metric System.

The fixed length of this meter was obtained from a most careful computation of the length of the distance from the equator of the earth to the north pole along the meridian passing through the city of Paris. The length of the said distance having been determined, in order to obtain from it a convenient measure as a basis for practical use it was divided into 10,000,000 equal parts; hence the meter is one ten-millionth of the distance from the equator to the poles, or one forty-millionth of the polar circumference of the earth. The measurements, by which the length of the meter was established, were so accurately made that later determinations by improved instruments and methods prove that the distinguished mathematicians who originally fixed the length of the meter did their work with sufficient accuracy for all practical purposes, and this *unit* is preserved for all time to come in the *prototype metre*, attested and certified copies of which have recently been furnished to the civilized nations of the earth by the International Bureau of Weights and Measures, which is maintained by contributions from twenty-two nations, among which are England and the United States. Having described the base upon which the foundation of the Metric System rests, I will explain the manner in which the units of the other measures are obtained, and show how each is dependent upon some decimal division or decimal multiple of this fundamental linear base, the meter.

The unit for surface is the *are*, which is represented by a square whose side is ten meters; the unit for capacity is the *liter*, which is a cube whose rectangular linear measurements are one-tenth

of a meter; the unit for solidity is a *cubic meter;* and the unit for weight is the *gram*, which is the weight of a cube of distilled water, at the temperature of greatest density, whose side is the hundredth part of a meter. A slight examination of the relations mentioned above will reveal the readiness by which the quantity of surface, capacity, solidity, or weight may be found when the linear dimensions of quantities are given. That is, that area in square tens of meters equals the number of ares; capacity in cubic tenths of a meter equals the number of liters; solidity is reckoned in cubic meters; and volume, in cubic hundredths of a meter, equals the number of grams of water; and to find the weight of any substance, all that is necessary is to find its contents in cubic hundredths of a meter and multiply by its specific gravity, and the product is the weight of the substance in grams.

I now ask your attention to the uniformity, significance, and simplicity of the nomenclature of this system.

Each of the above-named units has its decimal divisions and decimal multiples, the values of which are indicated by uniform and significant prefixes placed before the names of the units of the measures of the different kinds of quantity. The prefixes denoting the decimal divisions are derived from Latin, and, beginning with the smallest, are *milli*, meaning a thousandth; *centi*, meaning a hundredth; and *deci*, meaning a tenth.

No American certainly should find fault with these, for, besides their simplicity in representing divisions of the basic units of quantities to the thousandth part, they are already familiar to us in the use of money of the United States, in the terms mills, cents, and dimes, which are employed to represent the thousandth, the hundredth, and the tenth part of the unit of our money, the dollar.

The prefixes denoting the decimal multiples are of Greek origin, and are *Deka*, meaning ten; *Hekto*, meaning hundred; and *Kilo*, meaning thousand; the initial letter of each multiple being a capital, to suggest that its value is greater than the unit of the table.

All the denominations of measures of length, surface, capacity, solidity, and weight can be represented by the five units and these

six prefixes, with the additional term ton, so that only twelve separate names are required, which exhibits a wonderful simplicity of nomenclature when compared with the names of the measures now used, since the names of units of length alone are nearly double this number. In practice it is not always found necessary to use all these prefixes to indicate divisions and multiples. Thus, in computing area of land, the Hektare and its decimal divisions are the only denominations in practical use; hence the tables of measures are arranged in decimal uniformity, but only such divisions and multiples are introduced as are required in practical computations.

The tables of weights and measures usually given, excluding cubic measure, are four in number, and they are generally written in the form of our table of money, thus,

10 millimeters make 1 centimeter.
10 centimeters make 1 decimeter.
10 decimeters make 1 meter, etc.

But in order to express the relation of each multiple and submultiple to its associated unit, I prefer the following form of statements for the tables:

MEASURES OF LENGTH.

A millimeter is .001 of a meter.
A centimeter is .01 of a meter.
A decimeter is .1 of a meter.
A meter is the unit of length.
A Dekameter is 10 meters.
A Hektometer is 100 meters.
A Kilometer is 1,000 meters.

MEASURES OF AREA.

A centare is .01 of an are.
A deciare is .1 of an are.
An are is the unit of area.
A Dekare is 10 ares.
A Hektare is 100 ares.

MEASURES OF CAPACITY.

A milliliter is .001 of a liter.
A centiliter is .01 of a liter.
A deciliter is .1 of a liter.
A liter is the unit of capacity.
A Dekaliter is 10 litres.
A Hektoliter is 100 liters.
A Kiloliter is 1,000 liters.

TABLE OF WEIGHTS.

A milligram is .001 of a gram.
A centigram is .01 of a gram.
A decigram is .1 of a gram.
A gram is the unit of weight.
A Dekagram is 10 grams.
A Hektogram is 100 grams.
A Kilogram is 1,000 grams.
A Ton is 1,000 Kilograms.

As the above classification indicates, there is only one table for each kind of quantity, which is far preferable to the measures now in vogue, which, as I have already stated, have four different tables of length, three of capacity, and four of weights. The fifth, and last, superior feature of the Metric System, to which I will refer, is the incalculable advantage of a decimal notation. When treating of the objections to the measures now in use, I showed what laborious work is required in making reductions therein. Reductions in metric calculation, on the other hand, are effected by merely moving the decimal point or prefixing or affixing ciphers; for instance, in reducing measures of length from the lowest to the highest denominations in the two systems —that is, to change inches to miles—it is necessary to divide successively by 12, 3, 5½, and 320; while to reduce millimeters, the unit of which is only about one twenty-fifth of an inch in length, to Kilometers, the unit of which is a little more than six-tenths of a mile, and is used in the Metric System to indicate such distances as we represent by the mile, all that is required is to move the decimal point six places to the left. While the case with

which this latter reduction is made is sufficient to show the great superiority of the decimal notation, it is not the only advantage of the Metric System of lengths over our linear measure, for the ratio of the Kilometer to the millimeter is 15.78 times greater than the ratio of the mile to the inch; the mile containing 63,360 inches, while the Kilometer contains 1,000,000 millimeters. As previously stated, the system of measures already explained furnishes means for the measurement of all commodities of traffic; but in practice it is found, in manipulating with small quantities, as the chemist and the druggist are continually required to do, that tables of square and cubic measures composed of the squares and cubes of linear denominations are more convenient for use than those in which the *are* and the *liter* are the respective units. Here, again, the advantage of a decimal notation is forcibly shown. As the square millimeter is an extremely small quantity, it being the hundredth part of a square centimeter, and hence, square millimeters are hundredths of a square centimetre, the table of square measure commences with square centimetres, and is written as follows:—

TABLE OF SQUARE MEASURES.

100 cm.^{2} are equal to 1 dm.^{2}
100 dm.^{2} are equal to 1 m.^{2}
100 m.^{2} are equal to 1 Dm.^{2}

—this latter being equal to an are, the unit of the measures of area.

As this is a table for areas, and as similar areas are to each other as the squares of their like linear dimensions, the number of units in each preceding denomination is the square of 10, or 100 times the number of units in the succeeding one.

As cubic millimeters are so small, each being the thousandth part of a cubic centimeter, and their value is indicated in thousandths of a cubic centimeter, the table of cubic measure is thus written:

TABLE OF CUBIC MEASURES.

1,000 cm.^{3} are equal to 1 dm.^{3}
1,000 dm.^{3} are equal to 1 m.^{3}

As *similar* capacities and solids are to each other as the cubes

of their like linear dimensions, the number of units in each preceding denomination is the cube of 10, or 1,000 times the number of units in the succeeding one. The reductions by these tables are made with as great facility as by the tables in which the progression is by the simple decimal notation. In square measure the progression from one denomination to the next higher is by the square of the decimal or the centesimal notation, and hence, to change square centimeters to square decimeters, the quantity must be divided by 100, which is done by moving the decimal point two places to the left. In like manner, in cubic measure, the progression is by the cube of the decimal or the millesimal notation, and to change any cubic denomination to a higher or lower denomination, the divisor or multiplier must be 1,000, or the decimal point must be moved three places for a change to each successive denomination.

There is also an incidental advantage connected with the practical use of the Metric System, which is so important that I desire to present it with double emphasis. This is the fruitfulness of the system in furnishing smaller and larger, easily convertible and suitable, units of measurements for every conceivable kind of industry. As units of length suited to each particular purpose, and being either the standard base of linear measure itself or some decimal division or decimal multiple of the same, we have the meter for the manufacturer of textile fabrics, the dry goods merchant, and the builder; the decimeter, for the horse-jockey; the centimeter, for the manufacturer of all kinds of culinary utensils, the shoemaker, the tailor, the brickmaker, the plumber, the mechanical engineer, the architect, and the worker in metals; the millimeter, for the physicist in making his delicate calculations; the Dekametre, for the surveyor and the civil engineer; and the Kilometre, for the itinerary. The series of weights used in the Metric System also furnishes a suitable unit for weighing every article which must be handled in any business or profession. The gram is the most appropriate unit imaginable for the use of the chemist and the druggist; the Kilogram is especially adapted to trade in articles of ordinary daily consumption; and the ton of 1,000 Kilograms meets the demands of dealers in coal, iron, and other gross commodities.

The other measures are no less prolific sources for furnishing fitting units for different purposes; but enough has been said to show the wonderful adaptability of the Metric System to the uses of mankind.

Having consumed so much time in considering the constitution of the two systems of weights and measures, I shall have to present what I have to say under the two heads yet to be treated in the most condensed form.

In the first place, a verified standard meter, made of an invariable and indestructible alloy of platinum and iridium, is so securely preserved that its destruction is beyond present human possibility, and also carefully verified and certified copies of this standard meter are in the possession of all civilized nations.

In the second place, an International Metrological Bureau, composed of representatives from the nations adopting the Metric System, has the custody of this prototype meter, and directs the manufacture of attested copies of said meter to be supplied to all nations and associations which may wish them, so that accuracy and uniformity in all measures distributed throughout the world are secured.

Popularity of the Metric System.

Having stated that a verified standard meter is in safe deposit, and that the production of authenticated copies thereof is provided for, let us see with what favor this Metric System has met at the hands of civilized nations.

By governmental authority, the use of the Metric System is now obligatory in the following named countries:

In Europe: Austro-Hungary, Belgium, Finland, France, Germany, Greece, Italy, The Netherlands, Norway, Portugal, Roumania, Spain, Sweden, and Switzerland.

In Africa: Egypt and the French Colonies.

In America: Argentine Republic, Brazil, Chili, Ecuador, Guatemala, Mexico, Peru, United States of Colombia, Uruguay, and Venezuela.

In England there is a strong sentiment in its favor among men

of more advanced thought; in fact, in 1863 a bill passed the House of Commons by a large majority, making the use of the Metric System compulsory after three years; but the bill was not approved by the House of Lords. However, in 1864 a bill was passed by both houses legalizing the system, but not making its use obligatory.

All civilized nations of commercial importance, except Great Britain, Russia, Turkey, and the United States, have the Metric System in exclusive use at their custom-houses.

There yet remains to be mentioned what steps have been taken toward the final adoption of the Metric System in our own country.

For more than twenty years Congress has shown a disposition to meet the people more than half-way in this good work, both by legalizing the system and by furnishing the several States with sets of standard metric weights and measures. The following is the text of the law approved July 28, 1866:

"Be it enacted by the Senate and House of Representatives of United States in congress assembled, that from and after the passage of this act, it shall be lawful throughout the United States of America to employ the weights and measures of the Metric System, and no contract or dealing or pleading in any court shall be deemed invalid or liable to objection because the weights and measures expressed or referred to therein are weights or measures of the Metric System."

And the following act was approved July 27, 1866:

"Be it resolved by the Senate and House of Representatives of the United States of America in congress assembled, that the Secretary of the Treasury be, and he is hereby authorized and directed to furnish each State, to be delivered to the Governor thereof, one set of the standard weights and measures of the Metric System for the use of the States respectively."

The possibility of the convenience now experienced in the operations of the "General Postal Union," which was formed at Berne, Switzerland, in 1874, by a congress composed of representatives from all the countries of Europe (including even Russia), Egypt, and the United States, is an outcome of the Metric System.

As a result of the formation of this "Postal Union," the following act was passed by Congress, and approved June 22, 1874; namely, "The Postmaster-General shall furnish to the post-offices exchanging mails with foreign countries, and to such other offices as he may deem expedient, postal balances denominated in grams of the Metric System, fifteen grams of which shall be the equivalent, for postal purposes, of one half-ounce avoirdupois, and so on in progression." All foreign mail matter is weighed in accordance with the provisions of this act.

Every time that we pass a nickel or a fractional silver coin we are handling a practical illustration of the Metric System. Our five-cent piece weighs five grams. Our fractional silver coins represent metric weights also. The fifty-cent piece weighs 125 decigrams; the twenty-five-cent piece, 625 centigrams; and the ten-cent piece, 25 decigrams.

Besides these statutory provisions by Congress, the Metric System has been put into practical use in some of the departments of public service. The Metric System of Weights and Measures is exclusively used in all the work done in the Assay Department in the United States Mint in Philadelphia. Since 1878 the Metric System has been in exclusive use in the United States Marine Hospital Service.

The meter has been used in the operations of the Coast Survey ever since the organization of the service.

As all scientific treatises written in Continental Europe have the results of investigations stated in the Metric System, and because measurements used in making scientific investigations everywhere are almost exclusively metric, for several years past all the colleges of our country have made a knowledge of the Metric System a requisite for admission.

Recently many industrial and scientific associations of our country have become interested in metrological reform. The Western Association of Architects and the Boston Society of Civil Engineers deserve especial mention in this commendable work, the former of which, at a convention held in Chicago, November 19, 1886, adopted the following resolution:

"*Resolved*, That this Association recommend the adoption of the Metric System of Weights and Measures, and that the pres-

ident appoint a committee, whose duty it shall be to correspond with other organizations interested in this subject, and, in connection with them, petition Congress to pass a law making the use of the Metric System compulsory after a reasonable period."

In closing the third general division of my subject, let me recapitulate a few of the most important facts that we have learned. In the first place, we learn that we are using a complex, irrational, heterogeneous lot of measures, such as no other nation in the whole world employs.

In the second place, we learn that we have at hand, as an admirable substitute for these inconvenient measures, a simple, scientific, homogeneous system of measures, namely, the Metric System.

In the third place, we learn that almost all the civilized governments of the earth, both republican and monarchical, have compelled their subjects to use this system in legal transactions.

In the fourth place, we learn that the Government of the United States, the higher educational institutions, and the advocates of the advancement of social science have been opening the way for the exclusive use of the system in our own country.

In the fifth place, we learn that, as a people, we are sadly behind the age in metrological reform.

Means Suggested to Secure the Exclusive Use of the Metric System in the United States at an Early Date.

In the face of this array of incontestable evidence, both foreign and domestic, in favor of the Metric System, the question presents itself to us, What should we, as citizens of the United States, do in order to secure to ourselves the blessings that would accrue from the exclusive use of the Metric System in all business transactions?

It seems to me that the course that should be pursued by every intelligent citizen is very plain. He should devote a little time to the study of this simple and incomparably superior system of

weights and measures. It would not require more than an hour to learn and to understand thoroughly the whole system, and if any one is ignorant of the fact, I will state, for his information, that, through the influence of the American Metrological Society, every grammar-school or higher arithmetic published within the last ten years has in it the tables of the Metric System, with all necessary explanations. They occupy so little space in the books that most teachers, being entirely ignorant of their great value, and ignoring the fact that frequently the most precious articles come in small packages, pass them by unnoticed. Now, this state of things should be corrected, and I am thoroughly convinced that the time has come for our government to declare that within a prescribed period the exclusive use of the Metric System should be obligatory. There is not a shadow of doubt about the authority of government to do so.

The Constitution of the United States makes special provision for this very emergency in Article I., Section VIII., Clause 5, in these words: "Congress shall have power to coin money, regulate the value thereof, and of foreign coin, and to fix the standard of weights and measures." And in the eighteenth clause of the same section, "Congress is empowered to make all laws which shall be necessary and proper for carrying into execution the foregoing powers." These are merely general suggestions. As I believe in definite declarations and specific proposals, I would have laws enacted making the exclusive use of the Metric System obligatory in all kinds of government service after January 1, 1895, and in all transactions between citizens of the United States after December 31, 1900. This length of time is abundant to educate the people for the change. Let the Fifty-first Congress of the United States pass the obligatory act as soon as possible, and thus complete the good work commenced by the Thirty-ninth Congress when it adopted the Metric System as legal weights and measures of our country. Then let the President of the United States transmit to the governors of the States copies of the enacted law, with an earnest recommendation that the governors urge upon the legislatures of the different States the necessity of providing means for proper instruction in the Metric System in every school in the country.

Let every teacher in our land not only be a PAIDAGOGOS, but let him become an enthusiastic ANTHROPAGOGOS in the Metric System, and the education of both the rising generation and adult members of the community could be accomplished at very little additional expense to each school district by furnishing for each school building a plain set of metric apparatus, by providing for immediate instruction in the system, and by prohibiting after June, 1895, instruction in any other than the Metric System of Weights and Measures. All this accomplished, a new era would be inaugurated, new joys would be added to school life; both teacher and pupil would be greatly relieved; the mathematics of business, trades, and professions would be reduced to the minimum; international commerce would receive a strong impetus, every national, industrial, social, and personal interest would be highly promoted—all because a lot of complex, irrational, and heterogeneous weights and measures has been sunk into eternal oblivion by the substitution of the simple, scientific, and homogeneous Metric System.

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